AD/A-006 030

THE NOAA PASSIVE OPTICAL CROSSWIND MONITOR

G. R. Ochs, et al

National Oceanic and Atmospheric Administration

Prepared for:

Army Electronics Command

September 1974

NOTICES

Disclaimers

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

The citation of trade names and names of manufacturers in this report is not to be construed as Official Government indorsement or approval of commercial products or services referenced herein.

Disposition

Destroy this report when it is no longer needed. Do not return it to the originator.

The U. S. Army Electronics Command, Atmospheric Sciences Laboratory Scientific Monitor was Mr. T. H. Pries

Available as NOAA TM ERL WPL-11 from the
National Technical Information Service
Operations Division
Springfield, Virginia 22151

ia

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ECOM-74-2	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER: AD/A-006030	
4. TITLE (and Subtitle): THE NOAA PASSIVE OPTICAL CROSSWIND MONITOR	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): G. R. Ochs, G. F. Miller and E. J. Goldenstein	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: National Oceanic and Atmospheric Administration, Environmental Research Laboratories, Boulder, Colorado 80302	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: A43BXL 74-8013
11. CONTROLLING OFFICE NAME AND ADDRESS: Atmospheric Sciences Laboratory, US Army Electronics Command, White Sands Missile Range, New Mexico 88002	12. REPORT DATE: September 1974
	13. NUMBER OF PAGES: 20
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

1. Crosswind
2. Remote Sensing
3. Winds
4. Laser Crosswind System
5. Optical Crosswind System
6. Anemometry

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

We describe an optical instrument that measures crosswinds by observing the scintillation of naturally illuminated scenes. Operating instruction, adjustment procedures, and circuit diagrams are included.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

TABLE OF CONTENTS

	Page
ABSTRACT	1
1. INTRODUCTION	1
2. CALIBRATION AND USE OF THE INSTRUMENT	2
3. CIRCUITRY	3
4. REFERENCES	5
APPENDIX	7

THE NOAA PASSIVE OPTICAL CROSSWIND MONITOR

G. R. Ochs, G. F. Miller, and E. J. Goldenstein

We describe an optical instrument that measures crosswinds by observing the scintillation of naturally illuminated scenes. Operating instructions, adjustment procedures, and circuit diagrams are included.

1. INTRODUCTION

The instrument shown in figure 1 measures the transverse component of the wind across the direction of the line of sight between the instrument and a nearly arbitrary background. The wind is measured by analyzing the motion of the faint irregular patterns of the scintillating light reflected from the observed scene. These patterns arise from the refractive-index irregularities present in the atmosphere between the scene and the receiver. Since the irregularities are carried along by the wind, it is possible to deduce the transverse wind component by analyzing the light pattern at the receiver.

The instrument operates by observing one spatial wavelength in the received pattern with two intermeshed spatial filters that are displaced by one-fourth wavelength. The instrument then computes the slope of the normalized covariance, at zero delay, of the temporal light fluctuations seen by these filters. This slope is a function of the transverse wind, the distance to the scene, the distribution of refractive-index fluctuations along the path, and the light distribution in the illuminated background. The weighting function for the wind, that is, the contribution of the wind at various path positions to the measurements, is also affected by path length, C_n^2 distribution, and the scene. While the relationship of these variables is complex, it is possible to select spatial filter sizes for which the slope is very nearly proportional to the

Figure 1. The passive optical crosswind monitor.

mean transverse wind on horizontal paths for a variety of scenes. We describe the calibration procedure for obtaining a given set of weighting functions. An extensive discussion of the theory, experimental results, and different modes of operation are discussed in Clifford et al. (1974).

The instrument minimizes the effects of movement in the scene or of the receiver itself; nevertheless, movement and precipitation will seriously interfere with the measurement. Signal-to-noise levels are related to the chosen spatial wavelength, path length, C_n^2, and the scene. There may be times during daylight (especially in dark, overcast conditions) when the system will not operate because of a combination of these factors. A low variance detector activates a signal loss warning during these periods to indicate that the system is not working.

2. CALIBRATION AND USE OF THE INSTRUMENT

Three controls are used to calibrate the system, the micrometer on the optical unit, the calibration frequency adjust, and the full scale meter adjust. A frequency counter is required to check the calibration frequency.

In general, realizable wind weighting functions tend to peak near the receiver end of the path. However, there is a certain amount of flexibility, and various modes of operation are discussed in detail in Clifford et al. (1974). One particular calibration has the virtue of remaining nearly the same for a fairly wide variety of scenes and ranges. Figure 2 shows the weighting functions expected for a scene of average spatial spectral characteristics, for ranges of 4, 2, 1, and 0.5 km. The micrometer is set to 0.61 cm, which corresponds to a filter spatial wavelength of one Fresnel zone at 2 km. The calibration of the instrument will remain essentially the same over a range of 0.5 to 4 km with the calibration frequency set to 114 Hz, for a full scale setting of 10 m/sec.

To calibrate the signal processor for the setting described, proceed as follows. Connect a counter to the calibration frequency output. Turn the calibrate switch to either calibrate position. Then set the calibration frequency to 114 Hz on the counter, using the calibration frequency adjustment and, if necessary, the range switch provided. Set the full scale switch to 10 m/sec. Now set the full scale and zero adjustments on the wind meter, using the controls under the meter. Start by setting the full scale adjustment for minimum meter deflection, increasing until full scale deflection is attained. In the alternate position of the calibrate switch, check the opposite meter deflection. Adjust the zero and full scale setting until a symmetrical full scale deflection around zero is obtained. If the wind speed output is to be connected to recording gear, it is

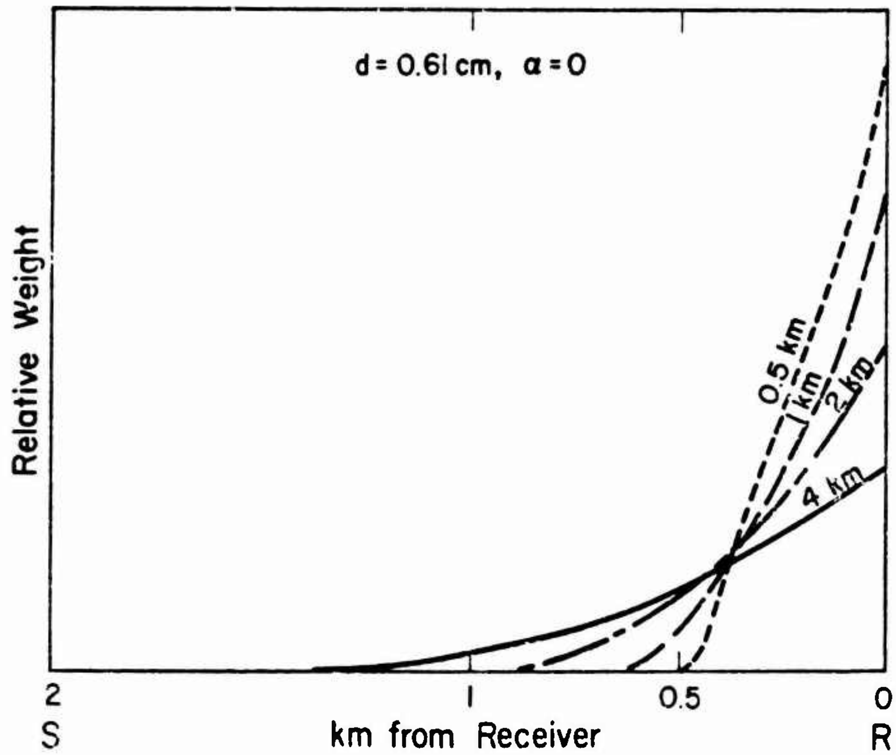

Figure 2. Wind weighting for scene distances of 0.5, 1, 2, and 4 km, for an average scene and a micrometer setting of 0.61 cm.

desirable to make the above adjustments with a digital voltmeter connected to this output. Two volts plus and minus correspond to full scale deflection on the meter.

Two other outputs are provided. The signal level output provides a voltage (20 dB/volt) proportional to the logarithm of the RMS signal fluctuation. The signal loss output is +5 volts when the signal loss light goes on, which indicates signal loss to recording equipment.

3. CIRCUITRY

Figure 3 is a block diagram of the system, which is a modified version of the signal processor described in Ochs and Miller (1973). Two measurements of the normalized covariance of the signals coming from the spatial filters are made; one with one signal lagging by the shift register time delay, and the second with the other signal lagging in time by the same amount. The difference between the two time-lagged covariance measurement is used as a measure of the slope of the function at zero delay. Since the arrays are in quadrature,

PASSIVE SYSTEM

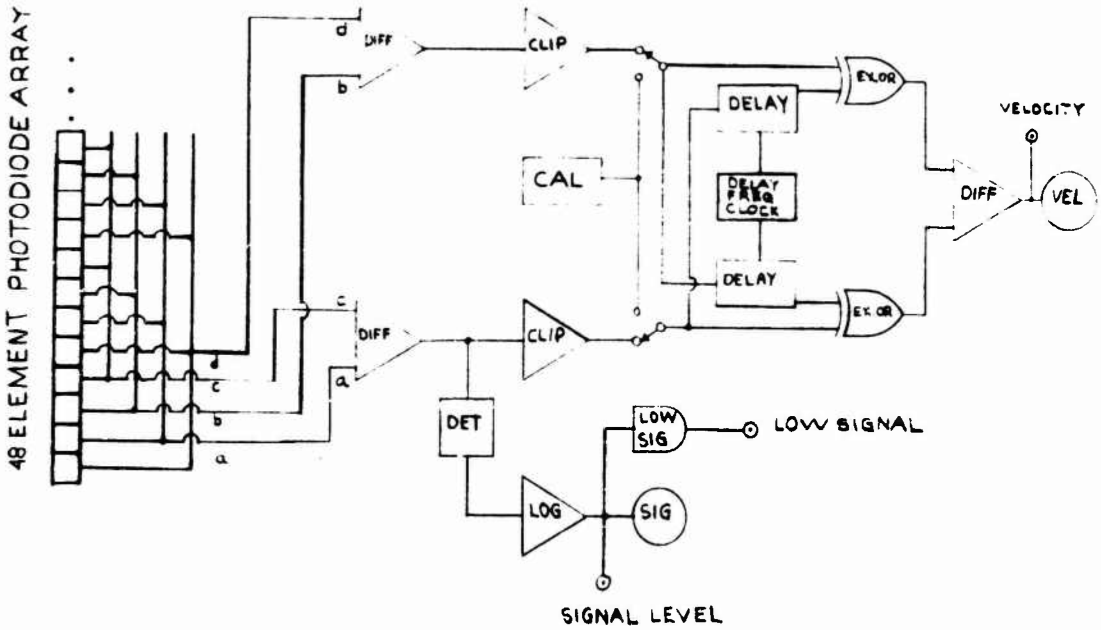

Figure 3. Block diagram of the system.

the covariance at zero delay is zero and it serves no purpose to make this measurement. For circuit stability, the difference between the two time-lagged covariance measurements is not taken directly. Rather, an equivalent circuit is used in which the analog sum of one covariance and the digitally inverted second covariance is obtained. COSMOS logic (see Appendix) is used to drive the difference amplifier to provide voltage stability in this circuit.

A calibration circuit furnishes square wave signals in quadrature and of variable frequency. These signals provide a convenient way of calibrating the system. Another circuit measures the logarithm of the signal fluctuation level. An output indicates when this signal is too low for satisfactory operation of the instrument.

4. REFERENCES

Clifford, S. F., G. R. Ochs, and Ting-i Wang (1974), Theoretical analysis and experimental evaluation of a prototype passive sensor to measure crosswinds, NOAA Tech. Report ERL 312-APL 35.

Ochs, G. R., and G. F. Miller (1973), The NOAA optical system for measuring average wind, NOAA Tech. Memo. ERL WPL-9.

APPENDIX A

Figures A1 through A12 are circuit diagrams of the printed circuit cards and panel wiring in the signal processor. In addition there are regulated power supply cards to provide +5 and $\pm$15 volts.

Adjustments to the system are not required in normal operation, but they are part of the initial alignment procedure. A description of the function and the method of adjustment follows.

<u>Receiver and photodiode preamplifier</u>--The micrometer zero setting may be adjusted as follows. With the equipment in operation observing a distant scene and with a cross wind present, set the micrometer to zero. The unit should read zero wind (average), as the arrays are at the focal plane. If it does not, remove the back plate on which the micrometer is mounted. The electronics, array, and micrometer are all attached to this plate. Unlock the slide with the lever under the array; move the array assembly slightly; and relock. Replace the plate; check the adjustment; and repeat until the proper setting is attained.

R1 and R2 (Fig. A1) equalize the amplifier gains for the plus and minus spatial filter components. Access is gained by removing the set screws in the micrometer back plate on the receiver. Point the receiver at a white wall illuminated by an incandescent light (AC). With a scope connected to the a-c and b-d test points on the signal processor panel, adjust R1 and R2 for minimum AC signal.

The remaining adjustments are located on the circuit cards inside the signal processor.

<u>Zero setting for precision detector</u>.

R3 (Fig. A2) - This adjustment should be set so that the signal level meter just goes off scale on the left when the instrument is pointing at a bright blue sky with no clouds.

R4 (Fig. A2) - This adjustment places the signal level meter in the proper range. Set approximately for 0 dB on the meter when observing under average conditions.

R5 (Fig. A4) - This control adjusts the dB level that activates the signal loss warning. A proper setting is approximately -40 dB, but varies with the settings of R3 and R4.

R6 and R7 (Fig. A5) - These adjust the zero crossover setting of the clippers. With the receiver cable disconnected, observe the test points on the clipper card with a scope and set both pots so that the test point signals are just flipping between high and low voltage levels.

R8, R9, and R10 - These are front panel controls; their operation is discussed in section 2.

R11 and R12 (Fig. A12) - These controls are internal gain adjustments for the wind speed panel meter and the wind speed output voltage. Although the external meter gain control is normally used in the calibration procedure, R12 must be initially adjusted so that the slope will be measured over the proper time interval. After this initial adjustment, the proper time interval is automatically selected by the normal calibration procedure. To adjust, set the calibration knob (front panel) to calibrate (either position) and the full scale knob to 10 m/sec. Connect a counter to the calibration output and adjust the calibration frequency to 120 Hz. Then connect the counter to the wiper of the full scale switch to observe the delay frequency. Set the delay frequency to 32 kHz with the front panel full scale adjust under the wind speed meter. Adjust R12 for 2 volts + and - at the wind speed output, in the two positions of the calibrate switch. It may be necessary to adjust the front panel zero under the meter for symmetrical deflection around zero. When this is complete, set the panel meter for full scale + and - by adjusting R11.

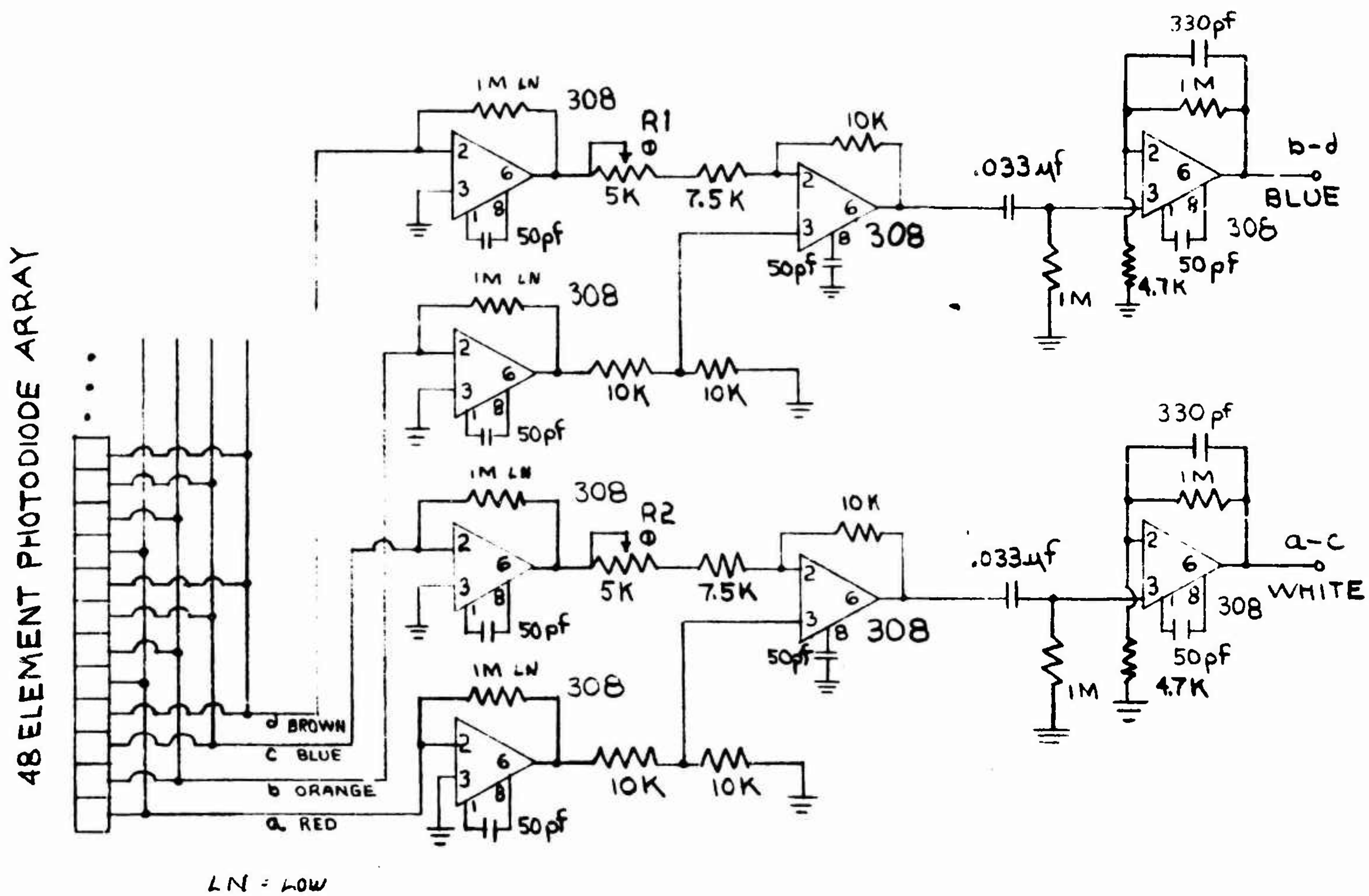

Figure A1. Circuitry of photodiode preamplifier mounted at receiver.

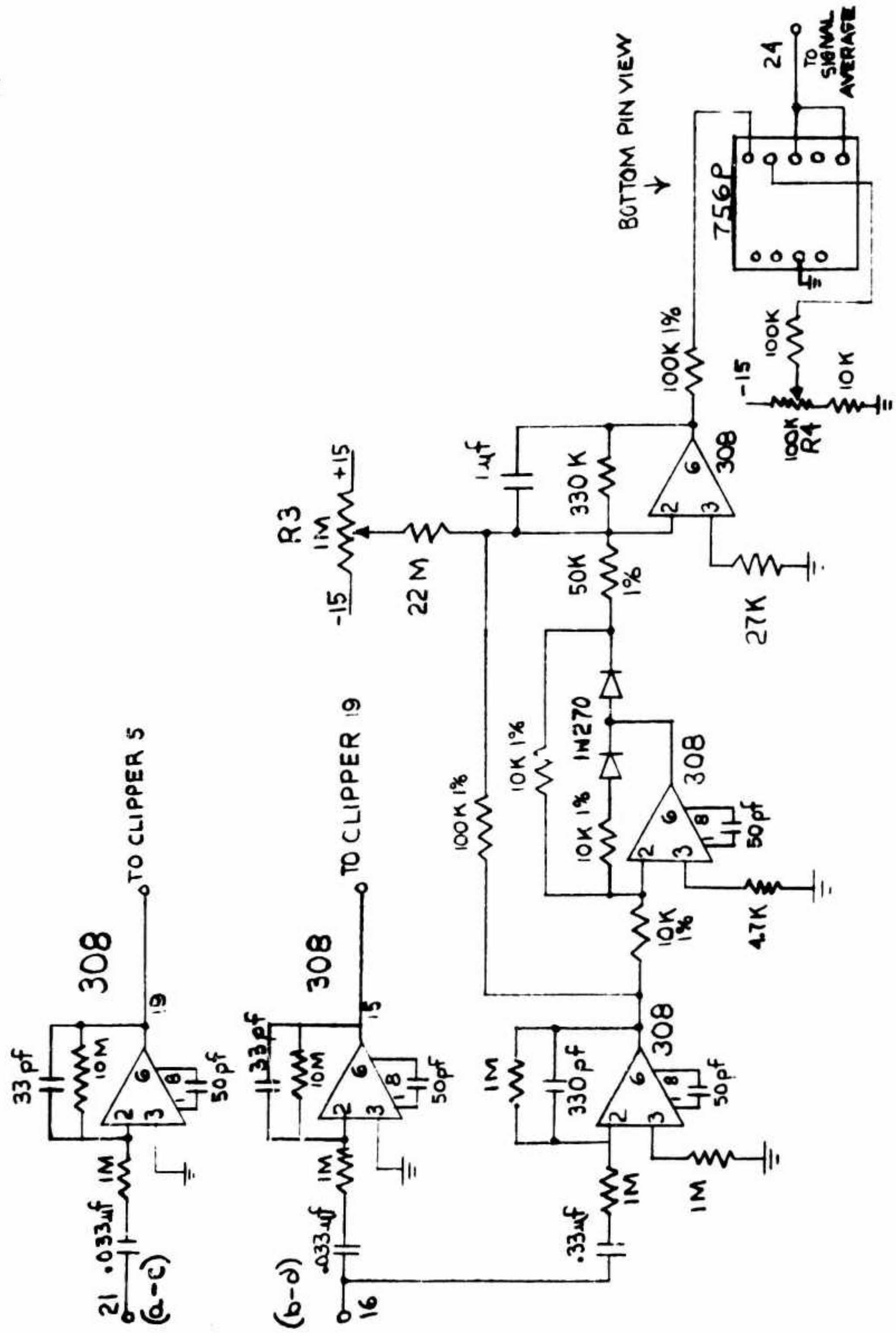

Figure A2. Spectrum card.

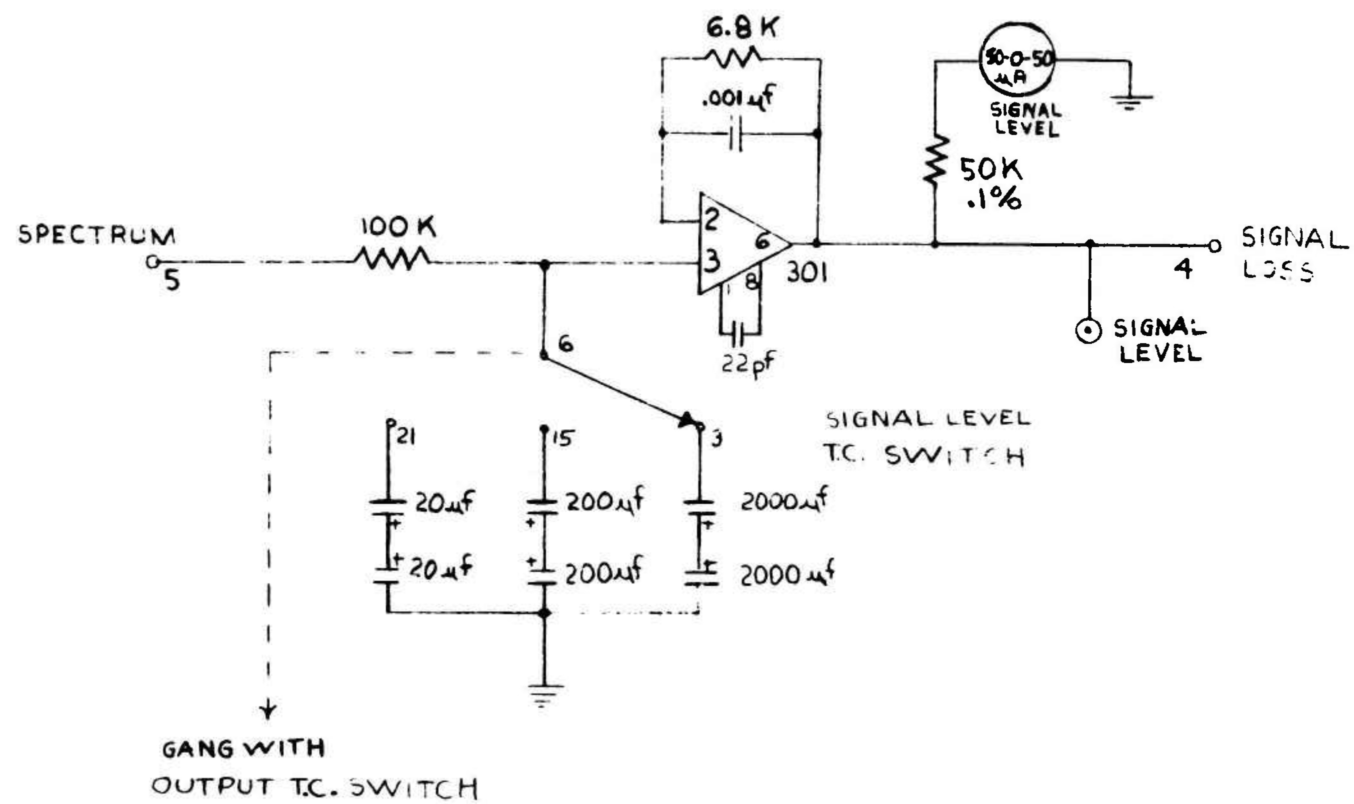

Figure A3. Signal level time constant card.

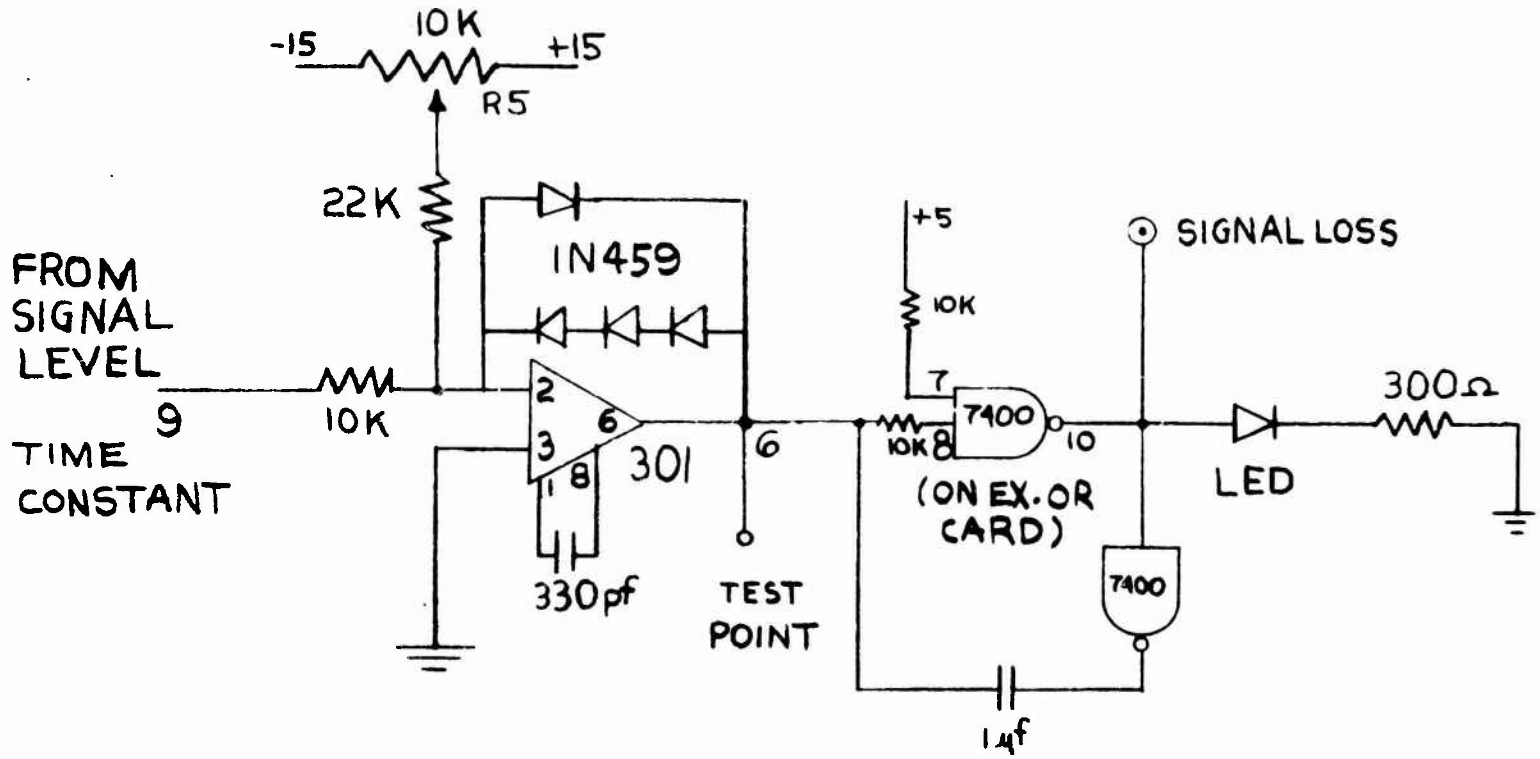

Figure A4. Signal loss card.

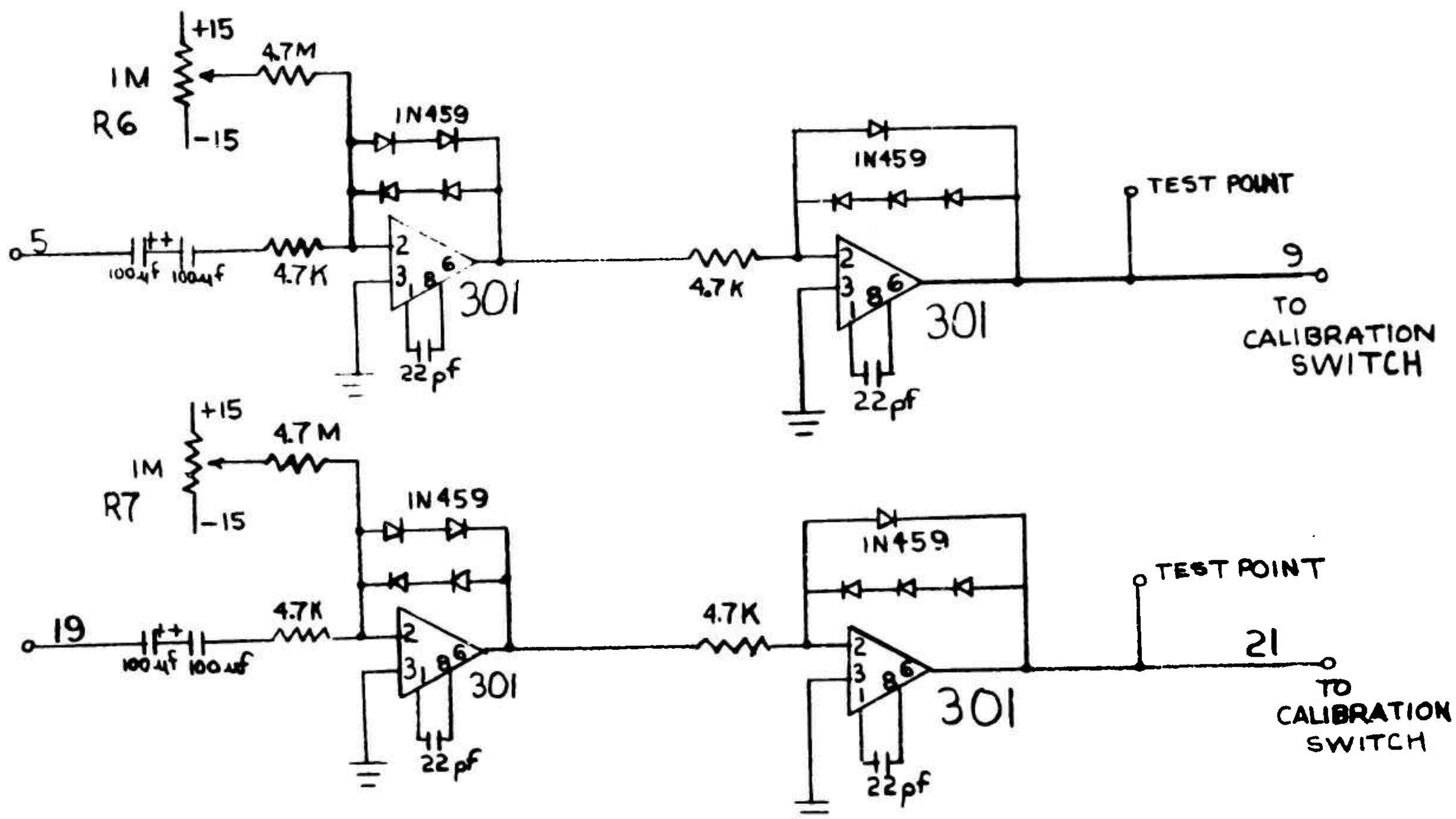

Figure A5. Clipper card.

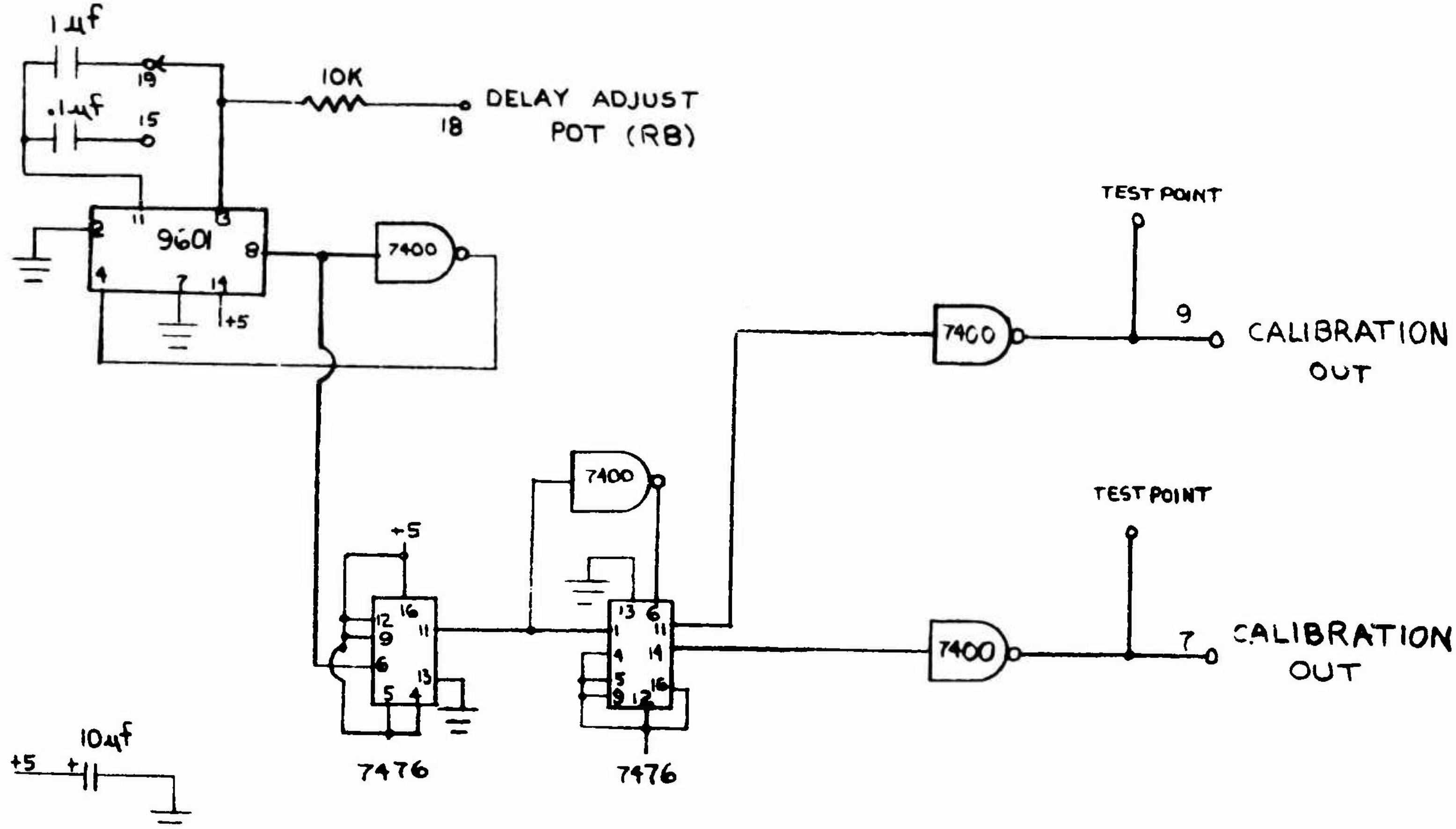

Figure A6. Calibration card.

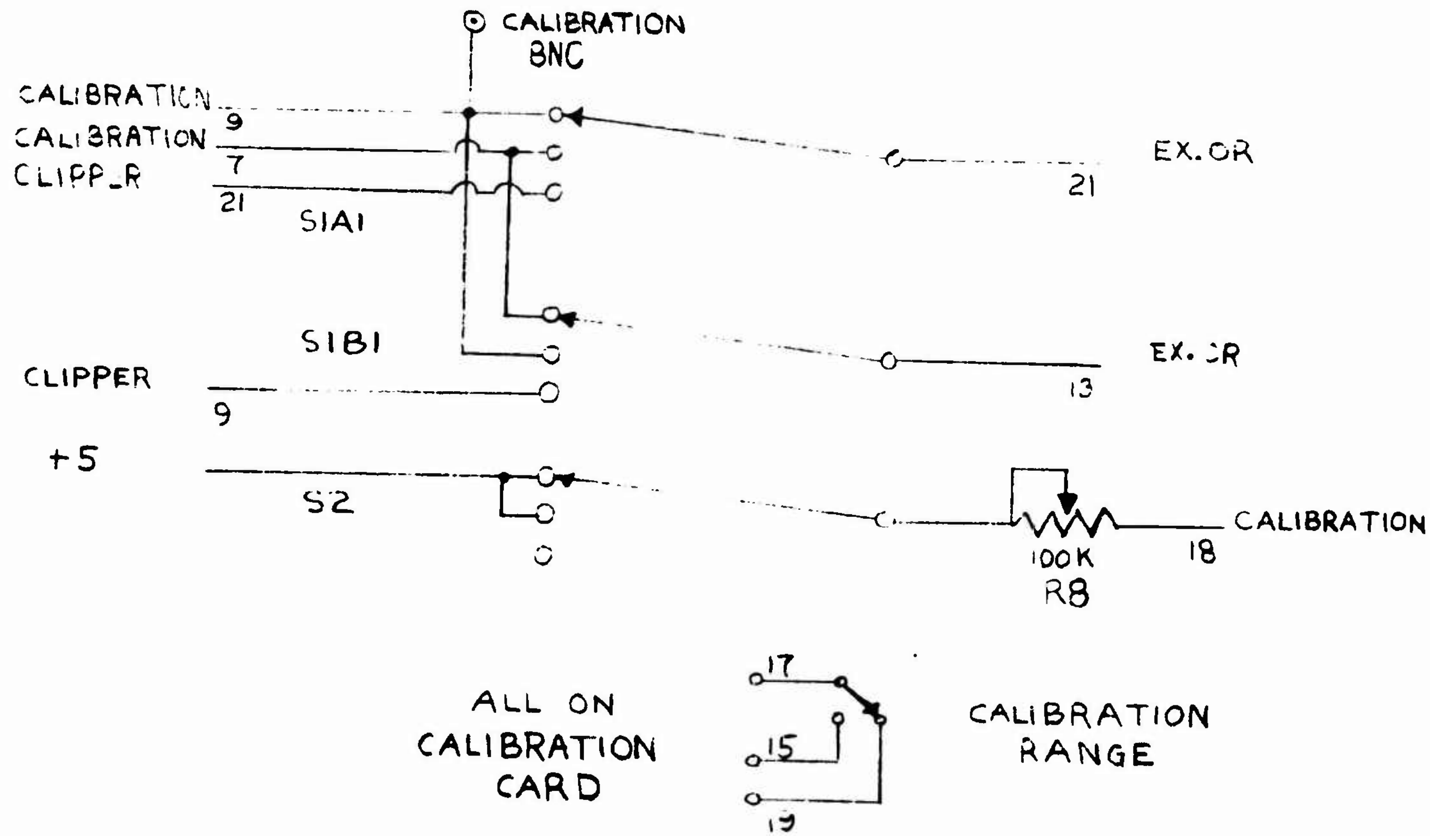

Figure A7. Calibration switch wiring (panel).

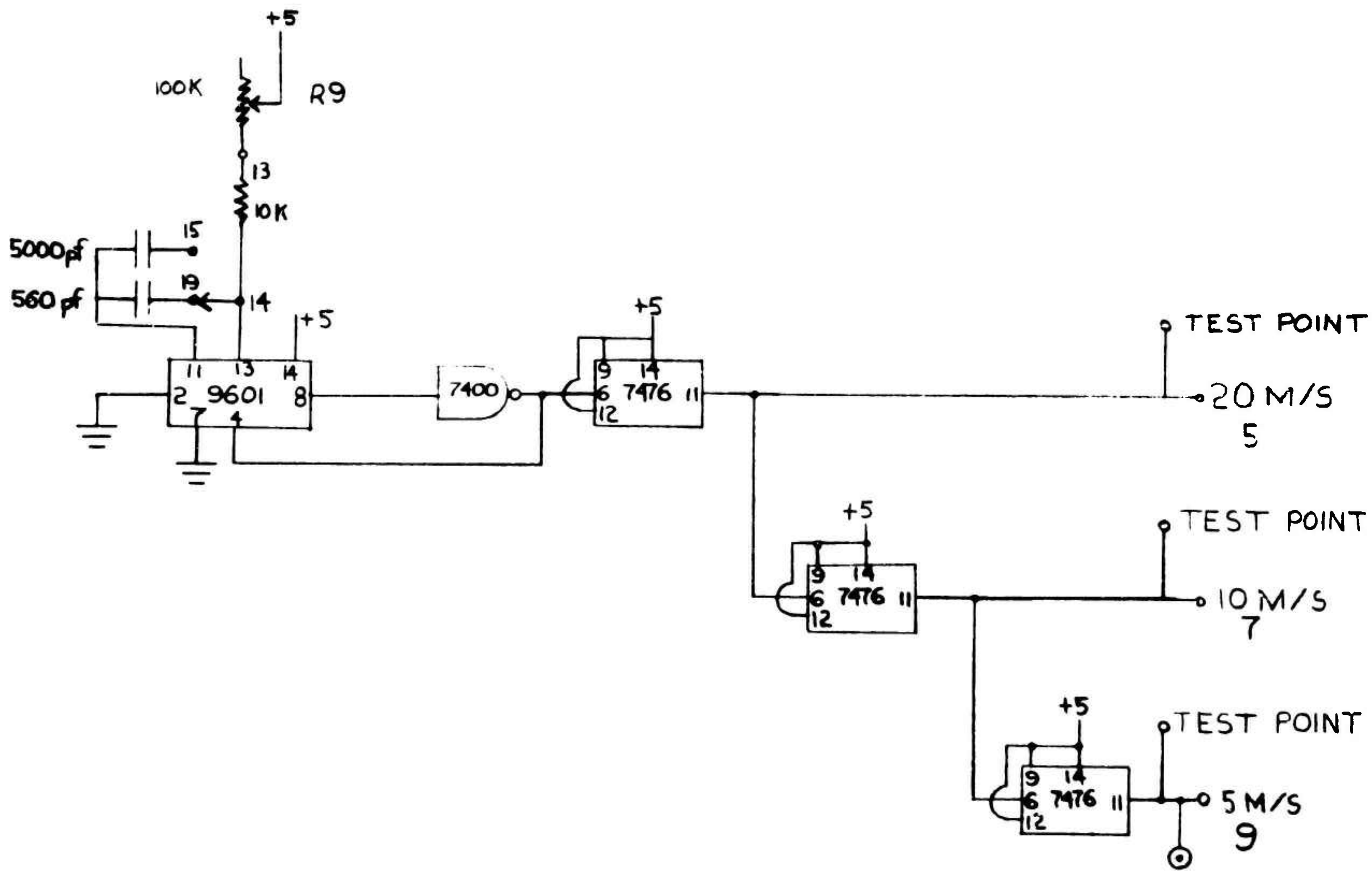

Figure A8. Delay frequency clock card.

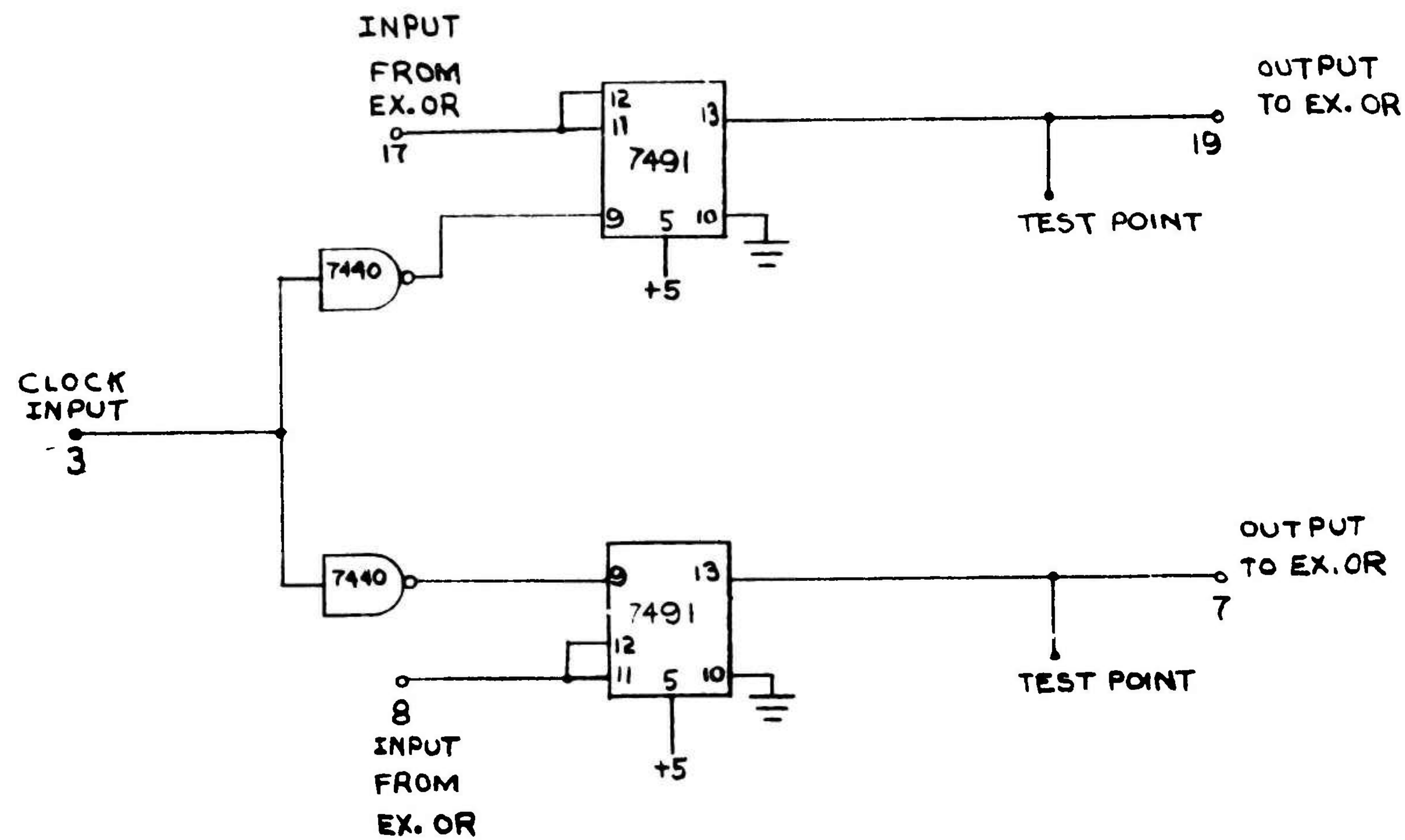

Figure A9. Dual eight-bit register card.

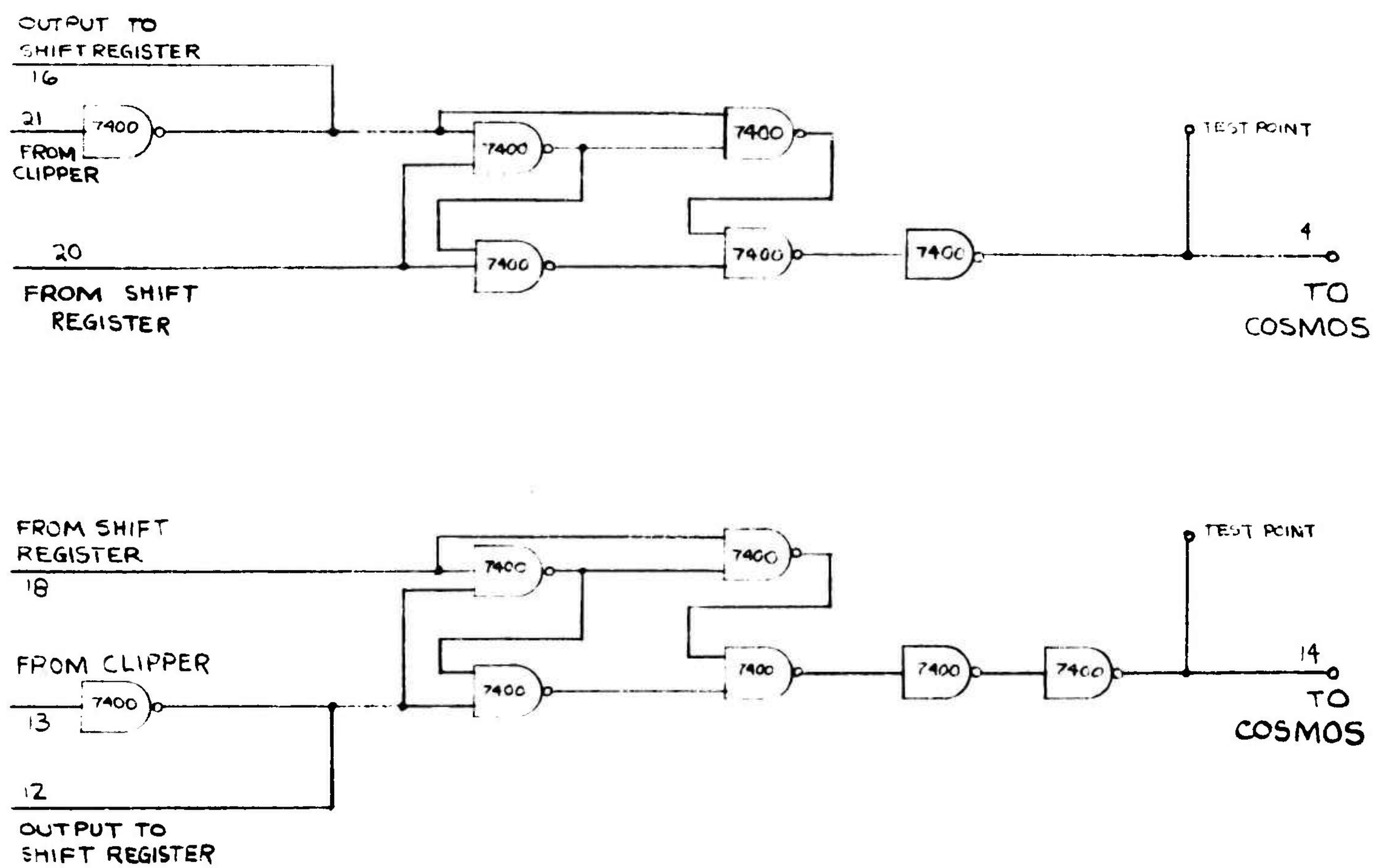

Figure A10. Exlusive OR card.

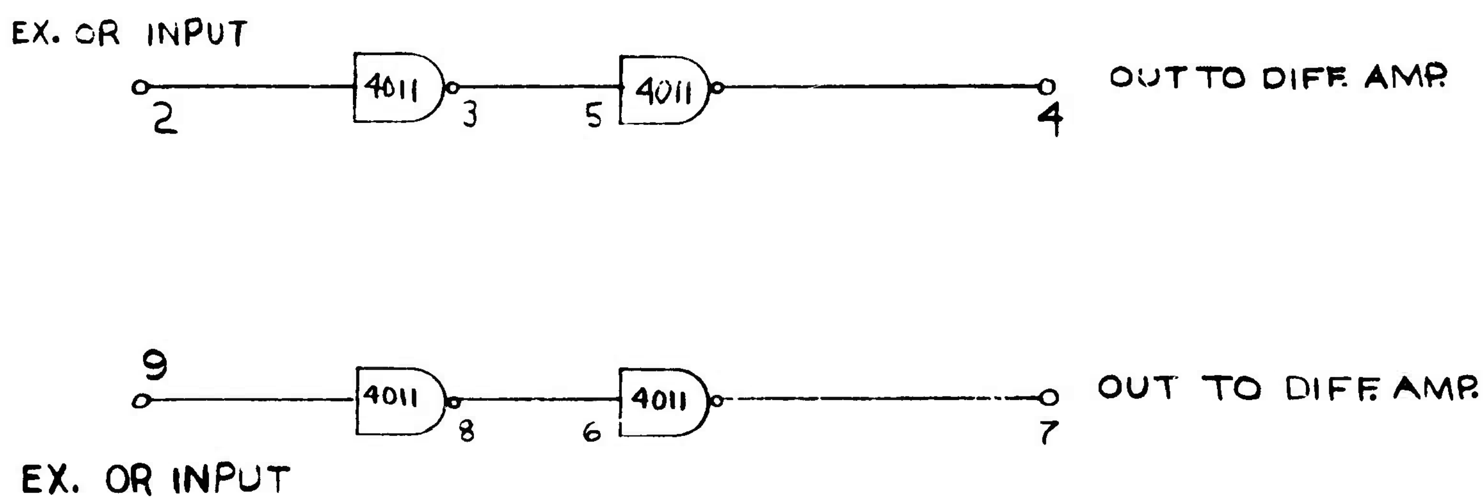

Figure A11. COSMOS card.

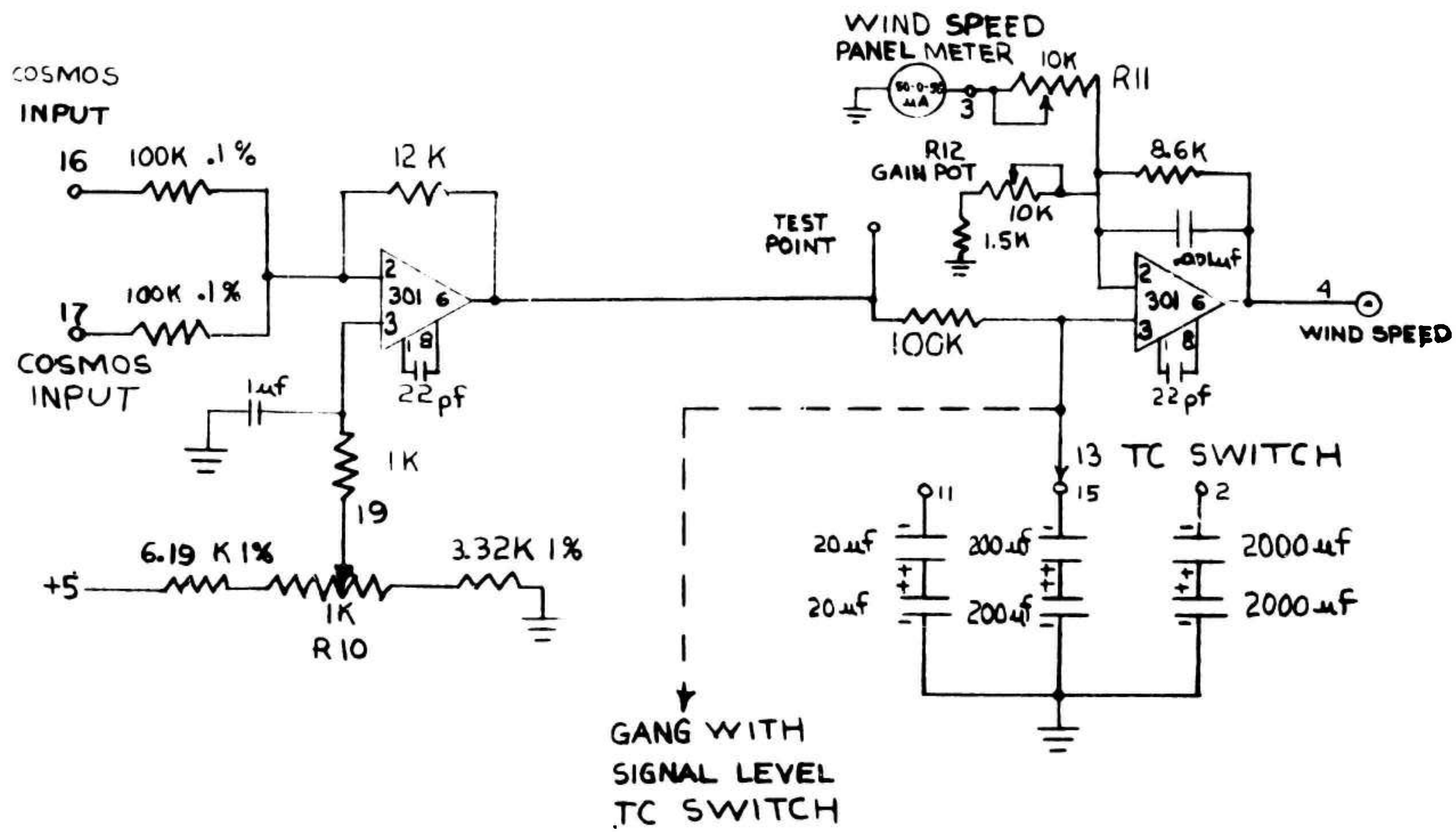

Figure A12. Difference correlation amplifier card.